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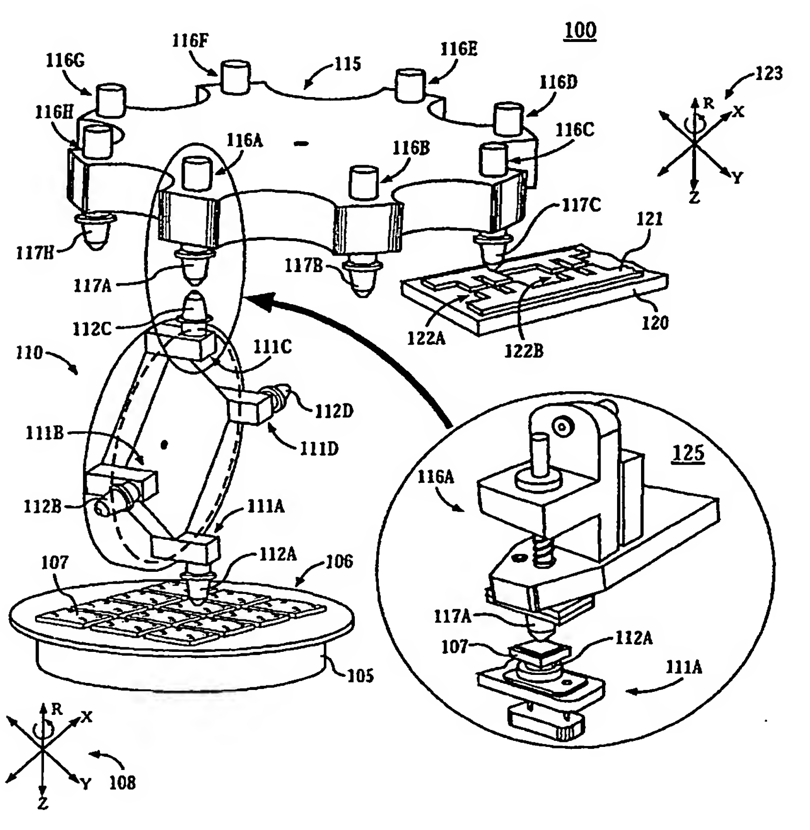

(57) Abstract: A flip bonder (100) has a pick-up turret assembly (110) with a number of pick-up nozzles (112A-D), and a placing turret assembly (115) with a number of placing nozzles (117 A-H). Each pick-up nozzle (112A-D) picks a die (107) by its bumped surface, and indexes the picked die (107) to the transfer location, thereby flipping the picked die (107). At the transfer location (310), the picked die is transferred to a placing nozzle (117A-H), with die now held by its back surface. The placing nozzle is indexed to a fluxing location where flux is applied to the die (107), and further indexed to a placing location, where the fluxed die (107) is placed on a target location (122A) on a leadframe (121), with the bumps abutting lead portions of the leadframe (121). The multiple nozzles (112A-D and 117 A-H) allow concurrent operations with each die (107), thus supporting an improved throughput.

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For two-letter codes and other abbreviations, refer to the "Guidance Notes on Codes and Abbreviations" appearing at the beginning of each regular issue of the PCT Gazette.

FLIP CHIP BONDER AND METHOD THEREFOR

Field of the Invention

The present invention relates to a flip chip bonder and method therefor, and more particularly to a flip chip bonder having an improved throughput.

Background of the Invention

Flip chip semiconductor packages are known, and with the need for smaller semiconductor packages driven, for example, by consumer demand for smaller portable products, the market for flip chip semiconductor packages is likely to grow significantly. Currently, flip chip bonders that are used in flip chip packaging have a throughput of about 4,000 units per hour, however with the expected growth in volume a substantially higher throughput is desirable.

A flip chip semiconductor package is one where a bumped semiconductor die is flipped over with its pattern of pads directly connected by the bumps, after reflow, to a corresponding pattern of terminals on a substrate or leadframe. The assembly of die, bumps and substrate or leadframe is then encapsulated in mold compound, and individual packages are subsequently singulated therefrom. An example is the quad-flat-non-leaded (QFN) package, which is molded and then sawn to singulate the individual packages.

When packaging semiconductor dies in flip chip packages, the semiconductor wafer that provides the dies is bumped. This is where bumps, typically of eutectic solder, are formed on the pads of the individual dies of the semiconductor wafer. The bumped semiconductor wafer is then sawn, and the sawn semiconductor wafer is mounted on an X-Y die pick-up table of a die bonder. During bumping, the semiconductor wafer is mounted with the pads exposed.

Consequently, after bumping, the bumped wafer is secured by it back surface one adhesive file, with its bumped side exposed. It is in this position that the bumped semiconductor wafer is sawn. This results in the singulated semiconductor dies of the wafer being secured with their bump side exposed on the adhesive film. As will be explained shortly, this poses some difficulty when packaging the semiconductor dies in flip chip semiconductor packages.

In a conventional non-flip chip die bonder, a bonding head moves horizontally between the die pick up stage, picks up a die by its pad side with typically a vacuum pick-up nozzle, and then moves back to a die placing location. The die placing location is aligned with a paddle on a leadframe, and upon arrival at the die placing location, the bonding head places the picked die on a paddle of a leadframe. Typically, a deposit of epoxy is disposed on the paddle prior to die placement, and when the semiconductor die is placed on the epoxy with a predetermined force by the bond head, the uncured epoxy cause the back surface of the die i.e. opposite the pad surface, to adhere to the paddle. Subsequently when the die, epoxy and leadframe are heated, the epoxy cures and bonds the die to the paddle.

In a flip chip bonder, the bumped die is lying in the same way with its back surface held by adhesive film and the bumps exposed. The flip chip bonder, has to pick up a bumped die by its bumped side, flip the bumped die over, apply flux to the bumps, and place the die on a leadframe, with the bumps on the die aligned with lead portions on the leadframe. Subsequently, when the bumped die, flux and leadframe are reflowed, the solder bumps melt and electrically and mechanically couple the pads on the die to the lead portions of the lead frame.

An example of a flip chip bonder is disclosed in US patent no. 6171049 by Wirz et al. and assigned to Alphasem AG of Switzerland. Wirz et al. teaches a flip chip bonder having a pick-up head for picking

dies from a mounted semiconductor wafer, an intermediate flipping member for receiving a die from the pick-up head and for flipping the die, and a placement head for picking up the flipped die from the intermediate flipping member, and for placing the die on a substrate

A disadvantage of Wirz et al. is the sequential action of picking, flipping and then placing each semiconductor die. This adversely affects the throughput of picking and placing dies in flip chip packaging. In addition, as there are two transfers of a die i.e. from the pick-up head to the intermediate flipping member, and then from the intermediate flipping member to the placement head, maintaining proper alignment of the placed semiconductor die, particularly smaller semiconductor dies will be tend to be difficult.

Another known die bonder apparatus combines a vertically rotating pick-up assembly having multiple heads which picks and flips a semiconductor die; and a placing head that travels horizontally between a transfer location and a placing location. Each head of the pick-up assembly picks a die from a wafer at a pick-up location, and is then rotated to flip the orientation of the die when the die is located at the transfer location. The placing head aligns with the pick-p head at the transfer location, and then picks up the die from the pick-up head. The placing head then moves horizontally back to the placing location, and then disposes the transferred die onto a substrate or leadframe.

Again, a disadvantage of this die bonder apparatus is the relatively low throughput, as the placing head always travels from the placing location to the transfer location without a die.

Brief Summary of the Invention

The present invention seeks to provide a flip chip bonder and a method therefor, which overcomes, or at least reduces, the abovementioned problems of the prior art.

Accordingly, in one aspect, the present invention provides a component mounting apparatus comprising:

at least one pick-up assembly having a plurality of pick-up heads, wherein each of the plurality of pick-up heads is adapted for picking at least one component having a picking orientation, for changing the orientation of the at least one component relative to the picking orientation to a transfer orientation, and for providing the at least one component having the transfer orientation at a transfer location; and

at least one placing assembly associated with the at least one pick-up assembly having a plurality of placing heads, wherein each of the plurality of placing heads is adapted for picking the at least one component having the transfer orientation at the transfer location from the each of the plurality of pick-up heads, and for disposing the at least one component having the transfer orientation at a placing location.

In another embodiment the present invention provides a method for mounting a plurality of components on a plurality of component carrier locations of a component carrier, the method comprising the steps of:

a) picking-up a first of the plurality of components at a pick-up location;

b) moving the first of the plurality of components from the pick-up location to a transfer location, thereby changing the orientation of the first of the plurality of components;

c) picking up a second of the plurality of components;

d) concurrent with step (c), releasing the first of the plurality of components for transfer at the transfer location; and

e) picking the first of the plurality of components at the transfer location;

f) moving the first of the plurality of components from the transfer location to a fluxing location;

g) applying flux to the first of the plurality of components;

h) concurrent with step (g), picking up a second of the plurality of components at the transfer location;

i) move the first of the plurality of components to a placing location;

j) concurrent with step (i), moving the second of the plurality of components to the fluxing location;

k) disposing the first of the plurality of components on a first of the plurality of component carrier locations; and

l) concurrent with step (k) picking up a third of the plurality of components and fluxing the second of the plurality of components.

In yet another embodiment the present invention provides a component mounting apparatus comprising:

at least one pick-up assembly having a plurality of pick-up heads, wherein each of the plurality of pick-up heads is adapted for picking at least one component having a picking orientation, and for providing the at least one component having the transfer orientation at a transfer location; and

at least one placing assembly associated with the at least one placing assembly having a plurality of placing heads, wherein each of the plurality of placing heads is adapted for picking the at least one component having the transfer orientation at the transfer location from the each of the plurality of pick-up heads, for changing the orientation of the at least one component relative to the transfer orientation to a placing orientation, and for disposing the at least one component having the placing orientation at a placing location.

Brief Description of the Drawings

An embodiment of the present invention will now be fully described, by way of example, with reference to the drawings of which:

FIG. 1 shows a schematic view of a flip chip bonder in accordance with the present invention;

FIGS. 2A-2B shows a flowchart detailing the operation of the flip chip bonder in FIG.1;

FIGS. 3A-3J shows a series of side sectional views of the flip chip bonder in FIG. 1 from a first perspective; and

FIGS. 4A-4J shows a series of side sectional views of the flip chip bonder in FIG. 1 from a second perspective.

Detail Description of the Drawings

A flip bonder is provided having a pick-up turret with a number of pick up heads, and a placing turret with a number of placing heads. The pick-up turret and the placing turret are arranged with their axes of rotation at right angels to each other, such that one of the pick-up heads and one of the placing heads are aligned at a transfer location. A singulated semiconductor wafer of bumped semiconductor dies is mounted on a movable mount, to provide a supply of semiconductor dies, and a leadframe is mounted on a movable mount providing a target for placing the bumped semiconductor dies. The dies on the movable mount are oriented with their back surface, i.e. the surface of the dies opposite the bumped surface, on the mount side. Each pick-up head picks one of the dies by its bumped surface, and moves the picked die to the transfer location, thereby flipping the picked die. At the transfer location, a placing head aligns with the picked die, which is still held by the pick-up head, and the die is transferred to the placing head, with the placing head holding the semiconductor die by its back surface. Subsequently, the bumps of the transferred die are dipped in flux at a fluxing location, and then at a placing location the fluxed die is placed on a target location on the leadframe, with the bumps abutting lead portions of the leadframe. Concurrently, as the picked die is transferred from the pick-up head to the placing head at the transfer location, another pick-up head picks up another die at the pick-up location. Such concurrent action advantageously allows

the flip-chip bonder of the present invention, as described, to provide improved throughput.

FIG. 1 shows a flip chip bonder 100, in accordance with the present invention, that includes a movable wafer mount 105, a pick-up turret assembly 110, a placing turret assembly 115, and a movable leadframe mount 120. The movable wafer mount 105 comprises an X-Y table, which is also capable of rotary movement. A singulated semiconductor wafer 106 (partially shown), comprising a number of bumped semiconductor dies (e.g. 107) typically secured by adhesive film (not shown), which is held on the movable wafer mount 105 by a vacuum. The movable wafer mount 105 can be moved along the X, Y, and Z axes, and rotated R about the Z axis, as indicated by a set of labeled arrows 108. The X-Y movement allows the movable wafer mount 105 to move along the X and Y reference axes on a common horizontal plane to align each die on the movable wafer mount 105 laterally with a reference pick-up location. In addition, the rotary R movement of the movable wafer mount 105 about the Z vertical axis allows a die, that is displaced at a radial angle, to be aligned radially at the pick-up location, prior to being picked off the movable wafer mount 105 by the pick-up turret assembly 110.

Optically assisted pick and place systems, as will be known to one skilled in the art, may be employed to determine the location and orientation of the die 107 on the movable wafer mount 105. The output of such optically assisted pick and place systems that employ optical detectors can then be provided to the movable wafer mount 105. The movable wafer mount 105 then moves to align the particular die 107 with the pick-up location. Further elaboration on optically assisted pick and place systems, will not be provided here, except to the extent that such elaboration facilitates a better understanding of the present invention, as described.

In one embodiment, additional movement of the movable wafer mount 105 along the Z-axis may be used during set up of the

equipment to set the distance between the pick-up turret assembly 110 and the dies 107 on the movable wafer mount 105. This setting can be made to ensure the pick-up turret assembly 105 picks up dies on the movable wafer mount 105 reliably and without damaging the dies, particularly dies which have a thickness that exceed two millimeters.

The pick-up turret assembly 110 comprises a circular arrangement of four pick-up heads 111A-111D on a common vertical plane, each equipped with a vacuum pick-up nozzle 112A-112D. The pick-up turret assembly 110 rotates about a fixed horizontal axis, sequentially moving or indexing each of the nozzles 112A-112D through four predetermined positions. The four positions include a pick-up location and a transfer location, which are opposite each other, and two other intermediate locations between the pick-up location and the transfer location. When at the pick-up location the nozzles 112A-112D each pick a die from the movable wafer mount 105, and at the transfer location the picked dies are sequentially transferred from the nozzles 112A-112D to the placing turret assembly 115.

The vacuum pick up nozzles 112A-112D are adapted to pick up the dies e.g. 107 from the movable wafer mount 105 by abutting the exposed bumped surface of the semiconductor die 107, and applying a vacuum to hold the bumped die 107 to the end of the nozzles 112A-112D. The four pick-up heads 111A-111D are spaced equally at ninety degrees from each other on the pick-up turret assembly 110. Each of the pick-up heads 111A-111D can include an independently controllable spring loaded actuator that can move the respective nozzles 112A-112D between a predetermined retracted position and a predetermined extended position.

In a preferred embodiment, a single stationary actuator is employed, and the stationary actuator is located to engage with each of the four pick-up heads 111A-111D, when any one of the pick-up

heads 111A-111D is at the pick-up location. When the actuator is activated, the nozzle, say 112A, at the pick up location is moved from the retracted position to the extended position. The nozzle 112A then picks up the die 107 from the movable wafer mount 105, and a spring returns the nozzle 112A to the retracted position. The nozzle 112A is then moved from the pick-up location to the transfer location by the rotation of the pick-up turret assembly 110.

In this embodiment, the pick-up turret assembly consists of a four-position indexer driven by an electric motor. A cam driven leverage mechanism is used as the actuator that operates with each of the pick-up heads 111A-111D to activate the movement of the nozzles 112A-112D from the predetermined retracted position to the predetermined extended position. In addition, four mechanical valves switch the vacuum to the nozzles 112A-112D ON and OFF.

Although a pick-up turret assembly 110 with two heads mounted opposite each other may be employed, the distance of travel of a die from the pick location to the transfer location through an angle of one hundred and eighty degrees and the short time travel time to meet the required throughput, poses the risk of a picked die flying off a pick-up nozzle due to centrifugal force thereon. The four-head arrangement reduces the distance of travel of the dies for a given throughput, thus reducing this risk. It will be appreciated by one skilled in the art that different die sizes and throughput requirements, may result in a pick-up turret assembly with more than four heads.

Another concern when rotating the pick-up turret assembly is its mass, and the resultant momentum, and the effect this has when the nozzles hold dies. A greater distance of travel results in greater momentum, making it more difficult to control the movement of the pick-up turret assembly so that its rotary movement is not jerky. This is necessary to prevent dies held by the nozzles from being displaced or dropped off. Again, dependent on the size of the die and the

required throughput a pick-up turret assembly having more than four heads may be used.

The placing turret assembly 115 comprises a circular arrangement of eight placing heads 116A-116H on a common horizontal plane, each equipped with a vacuum pick-up nozzle 117A-117H. Each of the placing heads 116A-116H can include an independently controllable actuator that can move their respective nozzles 117A-117H between a predetermined retracted position and a predetermined extended position. The placing turret assembly 115 rotates about a fixed vertical axis, sequentially moving each of the nozzles 117A-117H through the transfer location, a fluxing location, and a placing location. At the transfer location, the nozzles 117A-117H pick the die 107 provided at the transfer location by the nozzles 112A-112D of the pick-up turret assembly 110, employing the actuators in the placing heads 116A-116H. Then after moving to the fluxing location, the transferred die 107 is dipped in a flux container (not shown), again by activating the actuators in the placing heads 116A-116H. This applies flux to the bumps on the die 107. Then, the movable leadframe mount 120 aligns a target location 122A for the die 107 on a leadframe 121 with the placing location. When the transferred die 107 is moved to the placing location, the die 107 is then placed on the target location 122A, again employing the actuators of the placing heads 116A-116H.

The vacuum placing nozzles 117A-117H are adapted to pick up the semiconductor die 107 by abutting the back surface of the semiconductor die 107, and applying a vacuum to secure the bumped die 107 to the end of the nozzle 117A-117H. The eight placing heads 116A-116H are spaced equally apart at forty-five degrees on the placing turret assembly 115.

In the preferred embodiment, three stationary actuators are employed, and the three actuators are located to engage and operate with any one of the placing heads 116A-116H at the transfer location, the fluxing location and the placing location, respectively. When

either of the three actuators is activated, the nozzle, say 117A, at the transfer, fluxing or placing location is moved from the retracted position to the extended position. At the transfer location the extended nozzle 117A picks up the die 107 from, for example, the pick-up nozzle 112A, and a spring returns the nozzle 117A to its retracted position. Similarly, at the fluxing and placing locations, the nozzle 117A is moved between the retracted and extended position by the respective actuators for the respective locations. In addition, eight mechanical valves switch the vacuum to the nozzles 117A-117H ON and OFF. Further, the placing turret assembly 115 comprises an eight-position indexer driven by an electric motor. The movement of the nozzles 117A-117H from the predetermined retracted position to the predetermined extended position and the switching of the vacuum to the nozzles 117A-117H, are effected by clutch-brake mechanisms operating with the three actuators.

The movable leadframe mount 120 can be moved along the X, Y, and Z-axes, and rotated R about the Z-axis, as indicated by a set of arrows labeled 123. The movable leadframe mount 120 comprises an X-Y table (partially shown), which also includes a further rotary movement R, and movement along the Z-axis. The leadframe 121 (partially shown), comprising a number of target locations 122A, 122B, etc., is typically secured by a vacuum and/or clamp arrangement to the X-Y table. The X-Y movement allows the movable leadframe mount 120 lateral movement along X and Y reference axes on a common horizontal plane, to align each of the target locations 122A, 122B, etc. on the leadframe 121 with the reference placing location. In addition, the rotary movement R of the movable leadframe mount 120 about the vertical Z axis allows the target locations e.g. 122A, that is displaced at an angle, to be aligned at the placing location, prior to placing the semiconductor die 107. Again, optically assisted pick and place systems, as will be known to one skilled in the art, may be employed to determine the location and orientation of the target

location 122A. The output of such optically assisted pick and place systems can then be provided to the movable leadframe mount 120. Again, further elaboration on optically assisted pick and place systems, will not be provided here, except to the extent that such elaboration allows a better understanding of the present invention, as described.

In one embodiment, additional movement of the movable leadframe mount 120 along the Z axis may be used during set up of the equipment to set the distance between the placing turret assembly 115 and the leadframe 121 on the movable leadframe mount 120. This setting ensures the placing turret assembly 115 places the dies 107 on the leadframe 121 reliably and without damaging the dies 107, particularly dies with a thickness that exceeds two millimeters.

In a preferred embodiment, the placing turret assembly 115 moves the placing heads 117A-117H through two additional locations, a orientation detecting location and a standby location, after the fluxing location and before the placing location. At the orientation location, an optical orientation detector determines the orientation of the fluxed die, and compares this with the orientation of the target location on the leadframe 121 at the target location. The movable leadframe mount 120 is then moved to compensate for any differences in orientation.

Typically, a camera is used as the optical detector, and in the preferred embodiment of the flip chip bonder 100, a total of three cameras are employed in the vision pick and place system. One camera is directed at the dies on the movable wafer mount 105, another at the target locations of the leadframe on the movable leadframe mount, and a third at the fluxed die at the orientation detecting location.

An inset 125 shows more details of the pick-up head 111A with the nozzle 112A holding the semiconductor die 107, and aligned with the placing head 116A with nozzle 117A, at the transfer location. The

actuators in both the pick-up head 111A and the placing head 117A can be calibrated to set the travel of the nozzles 111A and 117A respectively, and the force exerted on the dies.

Although this description details picking and placing semiconductor dies on a leadframe, the present invention as described can be suitably adapted to pick and place any of a variety of components on component carriers where the orientation of the component at the pick-up location is different from the required orientation of the component on a component carrier at the placing location. Photo detectors are an example of such components. In addition, component carriers can comprise a variety of substrate and printed circuit boards for direct chip attach applications.

With reference to FIG. 2A and partial reference to FIGS. 3A-J and FIGS. 4A-J, the operation 202 of the pick-up turret assembly 110 starts 205 with the operation of the actuator in the pick-up head 111A causing the nozzle 112A to pick 210 the die 107A at the pick-up location. Of course, prior to picking, the die 107A is aligned with the pick-up nozzle 112A at the pick-up location by the X-Y wafer table 120. The pick-up turret assembly 110 then rotates or indexes through an angle of ninety degrees, moving 215 the die 107A away from the pick-up location to the transfer location, thereby flipping the die 107A. Concurrently, another nozzle 112B moves to the pick-up location.

Next, after another die 107B has been aligned with the pick-up location by the X-Y table 120, the nozzle 112B picks up another die 107B with the operation of the actuator in the pick-up head 111B. Subsequently, the pick-up turret assembly 110 rotates through a further angle of ninety degrees, moving the die 107A to the transfer location, concurrently moving the die 107B held by nozzle 112B away from the pick-up location, and moving another nozzle 112C to the pick-up location. With the two ninety-degree displacements, the orientation of the die 107A with respect, relative to its orientation at the pick-up location, is inverted or flipped. Then, concurrently 220,

the nozzle 112C picks another die 107C, and the nozzle 112A releases the die 107A at the transfer location for picking by the placing turret assembly 115. The operation 202 then returns to step 210, and repeats as previously described.

With reference to FIG. 2B and partial reference to FIGS. 3A-J and FIGS. 4A-J, the operation 204 of the placing turret assembly 115 starts 250 with one of the nozzles, say 117A, picking 255 the die 107A at the transfer location from the pick-up head 111A with the operation of the actuator in the placing head 116A. With the die 107A now held by its back surface, the turret assembly 115 rotates and moves the die 107A to a fluxing location. At the fluxing location the die is dipped, by operation of the actuator in the placing head 116A, in a fluxing container to apply 260 flux to the bumps of the die 107A. Concurrently, the actuator in the placing head 116B is activated to pick up another die 107B, which is now at the transfer location.

The placing turret assembly 115 then rotates to move 265 the die 107A to the placing location and to move the die 107B to the fluxing location. The die 107A is subsequently disposed 270 on the target location 122A by operation of the actuator in the pick-up head 111A, after the movable leadframe mount 120 aligns the target location 122A on the leadframe 121 with the placing location. Concurrently, the pick-up head 116B fluxes the die 107B at the fluxing location, and the pick-up head 116C picks up another die 107C that is now available at the transfer location. The operation 204 then returns to step 255 and repeats as previously described.

Reference will now be made to FIGS. 3A-J and FIGS. 4A-J with more details of the operation of the present invention, as described. With reference first to FIGS. 3A and 4A a number of dies of the singulated bumped semiconductor wafer 106, including the die 107A, are held on adhesive film 301, which is mounted on the movable wafer mount 105. The die 107A is aligned with a pick-up location 305 that

lies on a vertical reference axis 304. This is accomplished as previously described by the movable wafer mount 105.

The pick-up turret assembly 110 and the placing turret assembly 115 are fixed at a right angles relative to each other, such that one of the pick-up nozzles 112A-112D can align with one of the placing nozzles 117A-117H along the vertical reference axis 304 at the transfer location 310. As a starting point, for ease of description, the pick-up nozzle 112C and the placing nozzle 117G are shown aligned with the vertical reference axis 304 at the transfer location 310. Concurrently, another one of the pick-up nozzles 112A aligns with the vertical reference axis 304 at the pick-up location 305 to pick-up the die 107A; at the same time, another one of the placing nozzles 117F aligns with a fluxing axis 306 at a fluxing location 315; and another one of the placing nozzles 117E aligns with a placing axis 307 at a placing location 320.

A flux container 302 having flux 303 is located in a fixed position relative to the placing turret assembly 115, and the flux container is aligned with the fluxing axis 306 at the fluxing location 315. In addition, the movable leadframe mount 120 aligns the target location 122A of the leadframe 121 with the placing axis 307 at the placing location 320.

Next, with reference to FIGS. 3B and 4B, the actuator in the pick-up head 111A causes the nozzle 1112A at the pick-up location 305 to move to the extended position and abut the bumped surface of the die 107A. A vacuum is then applied via the nozzle 112A, and the vacuum holds the die 107A on the nozzle 112A. When the actuator in the pick up head 111A moves the nozzle 112A from the extended position to the retracted position, the die 107A is pulled off the adhesive film 301. The arrows 325 and 425 indicate the movement of the nozzle 112A between the extended and the retracted positions. Typically, a pin (not shown) within the movable wafer mount 105, aligns with the die 107A to be picked, and pushes upward against the back surface of

the die 107A to assist the nozzle 112A in picking the die 107A off the adhesive film 301. When smaller dies are picked, the pin forms point that often pierces through the adhesive film 301.

With reference now to FIGS. 3C and 4C, after the die 107A is picked, the pick-up turret assembly 110 and the placing turret assembly 115 rotate. The pick-up turret assembly 110 rotates 330 and 430 through an angle of ninety degrees to move the picked die 107A away from the pick-up location 305, and to align the pick-up nozzle 112B with the vertical reference axis 304 at the pick-up location 305. The movable wafer mount 105 then aligns another die 107B with the vertical reference axis 304 at the pick-up location 305. It will be appreciated, however, that the alignment of the die 107B can occur at any time after the die 107A has been picked but before the nozzle 112B picks the die 107B.

The placing turret assembly 115 rotates or indexes 332 and 432 through an angle of forty five degrees to align the nozzle 117H with the vertical reference axis 304, to align the nozzle 117G with the fluxing axis 306, and to align the nozzle 117F with the placing axis 307.

Referring to FIGS. 3D and 4D, the actuator in the pick-up head 111B causes the pick-up nozzle 112B to pick up the die 107B at the pick-up location 305. Again, this is accomplished by moving the pick-up nozzle112B between the extended and retracted positions, as shown by the arrows 335 and 435, and applying a vacuum, as described earlier. At this point, two dies 107A and 107B have been picked up off the movable wafer mount 105, and are held by the pick-up turret assembly 110.

In FIGS. 3E and 4E, after the die 107B is picked, the pick-up turret assembly 110 and the placing turret assembly 115 again rotate. The pick-up turret assembly 110 rotates 340 and 440 through a further angle of ninety degrees to move the die 107A to align with the vertical reference axis 304 at the transfer location 310 changing the

orientation of the die to be inverted or flipped. This indexing also moves the die 107B away from the pick-up location 305, and moves the pick-up nozzle 112C to align with the vertical reference axis 304 at the pick-up location 305. At the same time, the movable wafer mount 105 aligns yet another die 107C with the vertical reference axis 304 at the pick-up location 305.

The placing turret assembly 115 rotates 342 and 442 through an angle of another forty five degrees to align the nozzle 117A with the vertical reference axis 304, to align the nozzle 117H with the fluxing axis 306, and to align the nozzle 117E with the placing axis 307.

Hence, the pick-up turret picks up a bumped die by its bumped surface and inverts the picked die, advantageously presenting the back surface of the die for direct disposal on a leadframe or substrate, facilitating direct attachment of the flipped die.

Now referring to FIGS. 3F and 4F, the actuators in the placing head 116A and the pick-up head 111C operate concurrently. This causes the pick-up nozzle 112C to pick up the die 107C at the pick-up location 305, which as before is accomplished by moving the pick-up nozzle 112C between the extended and retracted positions, as shown by the arrows 345 and 445, and applying a vacuum, as described earlier. In addition, the placing nozzle 117A picks up the die 107A by its back surface from the pick-up nozzle 112A at the transfer location 310 while the vacuum at the pick-up nozzle 112A on the bumped surface of the die 107A is released. The actuator in the placing head 116A moving the placing nozzle 117A between the extended and retracted positions, as shown by the arrows 350 and 450, and applying a vacuum accomplishes this. To assist in the transfer of the die 107A from the pick-up nozzle 112A to the placing nozzle 117A, the vacuum at the pick-up nozzle 112A can be reduced instead of being switched off. This can reduce the likelihood of the die 107A from being dropped or missed.

With reference to FIGS. 3G and 4G, after the die 107A is transferred to the placing head 117A and the die 107C is picked, the pick-up turret assembly 110 and the placing turret assembly 115 again rotate concurrently. The pick-up turret assembly 110 rotates 360 and 460 through a further angle of ninety degrees to move the die 107B to align with the vertical reference axis 304 at the transfer location 310, and to move the die 107C away from the pick-up location 305. In addition, the pick-up nozzle 112D is aligned with the vertical reference axis 304 at the pick-up location 305, and the movable wafer mount 105 aligns another die 107CD with the vertical reference axis 304 at the pick-up location 305.

The placing turret assembly 115 rotates 355 and 455 through a further angle of forty five degrees to align the nozzle 117B with the vertical reference axis 304, to align the nozzle 117A holding the die 107Awith the fluxing axis 306, and to align the nozzle 117H with the placing axis 307.

Referring now to FIGS. 3H and 4H, the actuators in the placing head 116A, 116B and the pick-up head 111D are operated concurrently. This causes the pick-up nozzle 112D to pick up the die 107D at the pick-up location 305, which causes the pick-up nozzle 112D to move between the extended and retracted positions, as shown by the arrows 365 and 465, and applying a vacuum, as described earlier. Concurrently, the placing nozzle 117A moves between the extended and retracted positions at the fluxing location 315, as shown by the arrows 375 and 475, to dip the die 107A, and more particularly the bumps on the die 107A, in flux 303, and the placing nozzle 117B picks up the die 107B by its back surface from the pick-up nozzle 112B at the transfer location 310. This is accomplished by moving the placing nozzle 117B between the extended and retracted positions, as shown by the arrows 370 and 470, and applying a vacuum. At this point of the operation, two dies 107C and 107D are held by the pick-up turret assembly 110, and two dies 107A and 107B

are held by the placing turret assembly 115, with the die 107A having flux applied to its bumps.

Next, referring to FIGS. 3I and 4I, the pick-up turret assembly 110 and the placing turret assembly 115 again rotate concurrently. The pick-up turret assembly 110 rotates 385 and 485 through another ninety degrees to move the die 107C to align with the vertical reference axis 304 at the transfer location 310, and to move the die 107D away from the pick-up location 305. In addition, the pick-up nozzle 112A is again aligned with the vertical reference axis 304 at the pick-up location 305, and the movable wafer mount 105 aligns another die 107E with the vertical reference axis 304 at the pick-up location 305.

The placing turret assembly 115 rotates 380 and 480 through another forty-five degrees to align the nozzle 117C with the vertical reference axis 304. This rotation also aligns the nozzle 117B holding the die 107B with the fluxing axis 306, and aligns the nozzle 117A holding the fluxed die 107A with the placing axis 307. At this time, the target location 122A on the leadframe 121 has been aligned with the placing axis 307 at the placing location 320 by the movable leadframe mount 120.

Then, with reference to FIGS. 3J and 4J, the actuators in the placing heads 116A, 116B, 116C and the pick-up head 111A operate concurrently. This causes the pick-up nozzle 112A to pick up the die 107E at the pick-up location 305, which is accomplished by moving the pick-up nozzle 112A between the extended and retracted positions, as shown by the arrows 398 and 498, and applying a vacuum, as described earlier. Concurrently, the placing nozzle 117B moves between the extended and retracted positions at the fluxing location 315, as shown by the arrows 392 and 492, to dip the die 107B, and more particularly the bumps on the die 107B, in the flux 303. At about the same time, the placing nozzle 117C picks up the die 107C by its back surface from the pick-up nozzle 112C at the transfer location

310. This is accomplished by moving the placing nozzle 117C between the extended and retracted positions, as shown by the arrows 390 and 490, and applying a vacuum. Also at the same time the placing nozzle 117A places the fluxed die 107A on the target location 122A when the placing nozzle 117A moves between the extended and retracted positions as indicated by the arrows 396 and 496. At this point of the operation, two dies 107D and 107E are held by the pick-up turret assembly 110, and two dies 107B and 107C are held by the placing turret assembly 115, with the die 107B having flux applied to its bumps. In addition, the die 107A has been placed on the leadframe 121.

The steps as described in FIGS. 3A-3J and FIGS. 4A-4J are then repeated until dies have been placed at all the target locations on the leadframe 121, the leadframe 121 is then removed, and another leadframe is mounted on the movable leadframe mount 120. The leadframe 121 that is removed is later reflowed for the bumps on the die 107A to form solder interconnects with leads or pads on the leadframe 121. Similarly, when the dies on the movable wafer mount 105 are depleted another singulated bumped wafer is mounted on the movable wafer mount 105.

While the description of the present invention above is directed at the pick-up turret assembly picking and flipping the dies, and the placing turret assembly fluxing and placing the transferred dies, similar advantages are derived when the pick-up turret assembly picks the dies, and the placing turret assembly flips, fluxes, and places the dies. Of course, due to the rotation of the placing turret assembly, an alternative means of applying flux may be required, however, this can be addressed, for example, by dispensing the flux at the target location on the leadframe.

Hence, the present invention, as described, provides a flip chip bonder having an improved throughput.

This is accomplished by a pick-up turret and a placing turret, each turret having multiple nozzles. The pick-up and placing nozzles are synchronized so that each pick-up nozzle picks and flips dies, and concurrently each placing nozzle picks a flipped die from a pick-up nozzle, dips another die in flux and places yet another die on a leadframe. Due the multiple nozzles each holding a die for a separate operation i.e. picking a die, transferring a die from a pick-up to a placing nozzle, fluxing a die, and placing a die, these operations can be performed concurrently. The concurrency of operations advantageously improves the throughput of the flip chip bonder, as described.

The present invention therefore provides a flip chip bonder and a method therefor, which overcomes, or at least reduces, the abovementioned problems of the prior art.

It will be appreciated that although only one particular embodiment of the invention has been described in detail, various modifications and improvements can be made by a person skilled in the art without departing from the scope of the present invention.

Claims

1. A component mounting apparatus comprising:

at least one pick-up assembly having a plurality of pick-up heads, wherein each of the plurality of pick-up heads is adapted for picking at least one component having a picking orientation, for changing the orientation of the at least one component relative to the picking orientation to a transfer orientation, and for providing the at least one component having the transfer orientation at a transfer location; and

at least one placing assembly associated with the at least one pick-up assembly having a plurality of placing heads, wherein each of the plurality of placing heads is adapted for picking the at least one component having the transfer orientation at the transfer location from the each of the plurality of pick-up heads, and for disposing the at least one component having the transfer orientation at a placing location.

2. A component mounting apparatus in accordance with claim 1 further comprises at least one movable component mount for providing the at least one component having the picking orientation relative to the each of the plurality of pick-up heads at a pick-up location.

3. A component mounting apparatus in accordance with claim 2 wherein the at least one movable component mount further comprises an input for receiving component orientation data indicating orientation of the at least one component, and the at least one movable component mount for orientating the at least one component to have the picking orientation relative to the each of the plurality of pick-up heads at the pick-up location.

4. A component mounting apparatus in accordance with claim 3 further comprising a component orientation detector operably coupled to the at least one movable component mount for detecting the orientation of the at least one component on the at least one movable component mount, and for providing the component orientation data.

5. A component mounting apparatus in accordance with claim 4 wherein the at least one movable component mount comprises at least one movable mount that can move along an X and a Y reference axis, and that rotates about a Z reference axis.

6. A component mounting apparatus in accordance with claim 5 wherein the at least one movable mount that can move along an X and a Y reference axis, and that rotates about a Z reference axis, is adapted to additionally move along the Z reference axis.

7. A component mounting apparatus in accordance with claim 4 wherein the component orientation detector comprises an optical detector directed at the at least one component.

8. A component mounting apparatus in accordance with claim 1 further comprises at least one movable component carrier mount for providing at least one component carrier having at least one component carrier location thereon, the at least one movable component carrier mount for orientating the at least one component carrier location relative to the transfer orientation of the at least one component at the placing location to receive the at least one component.

9. A component mounting apparatus in accordance with claim 8 wherein the at least one movable component carrier mount further comprises an input for receiving component carrier location

orientation data indicating orientation of the at least one component carrier location, and the at least one movable component carrier mount for orientating the at least one component carrier location to have the transfer orientation relative to the at least one component at the placing location.

10. A component mounting apparatus in accordance with claim 9 further comprising a component carrier location orientation detector coupled to the at least one movable component carrier mount for detecting the orientation of the at least one component carrier location on the at least one movable component carrier mount, and for providing the component carrier location orientation data.

11. A component mounting apparatus in accordance with claim 8 wherein the at least one movable component carrier mount comprises at least one movable mount that can move along an X and a Y reference axis, and that rotates about a Z reference axis.

12. A component mounting apparatus in accordance with claim 11 wherein the at least one movable mount that can move along an X and a Y reference axis, and that rotates about a Z reference axis, is adapted to move along the Z reference axis.

13. A component mounting apparatus in accordance with claim 10 wherein the component carrier location orientation detector comprises an optical detector directed at the at least one component carrier location.

14. A component mounting apparatus in accordance with claim 1 wherein the at least one pick-up assembly having the plurality of pick-up heads comprises a substantially circular rotatable picking member having the plurality of pick-up heads spaced apart along its periphery.

15. A component mounting apparatus in accordance with claim 14 wherein the at least one placing assembly having the plurality of placing heads comprises a substantially circular rotatable placing member having the plurality of placing heads spaced apart along its periphery.

16. A component mounting apparatus in accordance with claim 15 wherein the plurality of pick-up heads extend radially relative to the axis of rotation of the substantially circular rotatable picking member, and wherein the plurality of placing heads extend substantially in parallel with the axis of rotation of the substantially circular rotatable placing member.

17. A component mounting apparatus in accordance with claim 15 wherein the plurality of pick-up heads extend substantially in parallel with the axis of rotation of the substantially circular rotatable picking member, and wherein the plurality of placing heads extend radially relative to the axis of rotation of the substantially circular rotatable placing member.

18. A component mounting apparatus in accordance with claim 1 wherein the at least one placing assembly having the plurality of placing heads comprises a substantially circular rotatable member having the plurality of placing heads along its periphery in a spaced apart relationship therebetween.

19. A component mounting apparatus in accordance with claim 18 wherein the each of the plurality of placing heads comprises at least one actuator operably coupled to at least one vacuum nozzle, the at least one actuator for moving the at least one vacuum nozzle between a predetermined retracted position and a predetermined extended

position, the at least one vacuum nozzle for picking up the at least one component when in the predetermined extended position at the transfer location, the at least one vacuum nozzle for holding the at least one component when in the predetermined retracted position, and the at least one vacuum nozzle for releasing the at least one component when in the predetermined extended position at the placing location.

20. A method for mounting a plurality of components on a plurality of component carrier locations of a component carrier, the method comprising the steps of:

a) picking-up a first of the plurality of components at a pick-up location;

b) moving the first of the plurality of components from the pick-up location to a transfer location, thereby changing the orientation of the first of the plurality of components;

c) picking up a second of the plurality of components;

d) concurrent with step (c), releasing the first of the plurality of components for transfer at the transfer location; and

e) picking the first of the plurality of components at the transfer location;

f) moving the first of the plurality of components from the transfer location to a fluxing location;

g) applying flux to the first of the plurality of components;

h) concurrent with step (g), picking up a second of the plurality of components at the transfer location;

i) move the first of the plurality of components to a placing location;

j) concurrent with step (i), moving the second of the plurality of components to the fluxing location;

k) disposing the first of the plurality of components on a first of the plurality of component carrier locations; and

l) concurrent with step (k) picking up a third of the plurality of components and fluxing the second of the plurality of components.

21. A method in accordance with claim 20 prior to step (a) comprising the step of aligning the first of the plurality of components at the pick-up location.

22. A method in accordance with claim 20 after step (a) and before step (b) further comprising the steps of moving the first of the plurality of components away from the pick-up location to at least one intermediate location, and subsequently moving the first of the plurality of components to the transfer location.

23. A method in accordance with claim 20 after step (g) and before step (i) comprising the steps of:

moving the first of the plurality of components to an orientation determining location to determine the orientation of the first of the plurality of components;

comparing the orientation of the first of the plurality of components with the orientation of the first of the plurality of component carrier locations at the placing location; and

changing the orientation of the first of the plurality of component carrier locations at the placing location to become substantially similar to the orientation of the first of the plurality of components.

24. A method in accordance with claim 23 after the step of changing the orientation of the first of the plurality of component carrier locations and before step (i) comprising the step of moving the first of the plurality of components to a standby location.

25. A component mounting apparatus comprising:

at least one pick-up assembly having a plurality of pick-up heads, wherein each of the plurality of pick-up heads is adapted for picking at least one component having a picking orientation, and for providing the at least one component having the transfer orientation at a transfer location; and

at least one placing assembly associated with the at least one placing assembly having a plurality of placing heads, wherein each of the plurality of placing heads is adapted for picking the at least one component having the transfer orientation at the transfer location from the each of the plurality of pick-up heads, for changing the orientation of the at least one component relative to the transfer orientation to a placing orientation, and for disposing the at least one component having the placing orientation at a placing location.

26. A component mounting apparatus in accordance with claim 25 wherein the at least one pick-up assembly having the plurality of pick-up heads comprises a substantially circular rotatable picking member having the plurality of pick-up heads spaced apart along its periphery.

27. A component mounting apparatus in accordance with claim 26 wherein the at least one placing assembly having the plurality of placing heads comprises a substantially circular rotatable placing member having the plurality of placing heads spaced apart along its periphery.

28. A component mounting apparatus in accordance with claim 27 wherein the plurality of pick-up heads extend substantially in parallel with the axis of rotation of the substantially circular rotatable picking member, and wherein the plurality of placing heads extend radially relative to the axis of rotation of the substantially circular rotatable placing member.

29. A component mounting apparatus in accordance with claim 25 wherein the at least one placing assembly having the plurality of placing heads comprises a substantially circular rotatable member having the plurality of placing heads along its periphery in a spaced apart relationship therebetween.

30. A component mounting apparatus in accordance with claim 29 wherein the each of the plurality of placing heads comprises at least one actuator operably coupled to at least one vacuum nozzle, the at least one actuator for moving the at least one vacuum nozzle between a predetermined extended position and a predetermined retracted position, the at least one vacuum nozzle for picking up the at least one component when in the predetermined extended position at the transfer location, the at least one vacuum nozzle for holding the at least one component when in the predetermined retracted position, and the at least one vacuum nozzle for releasing the at least one component when in the predetermined extended position at the placing location.

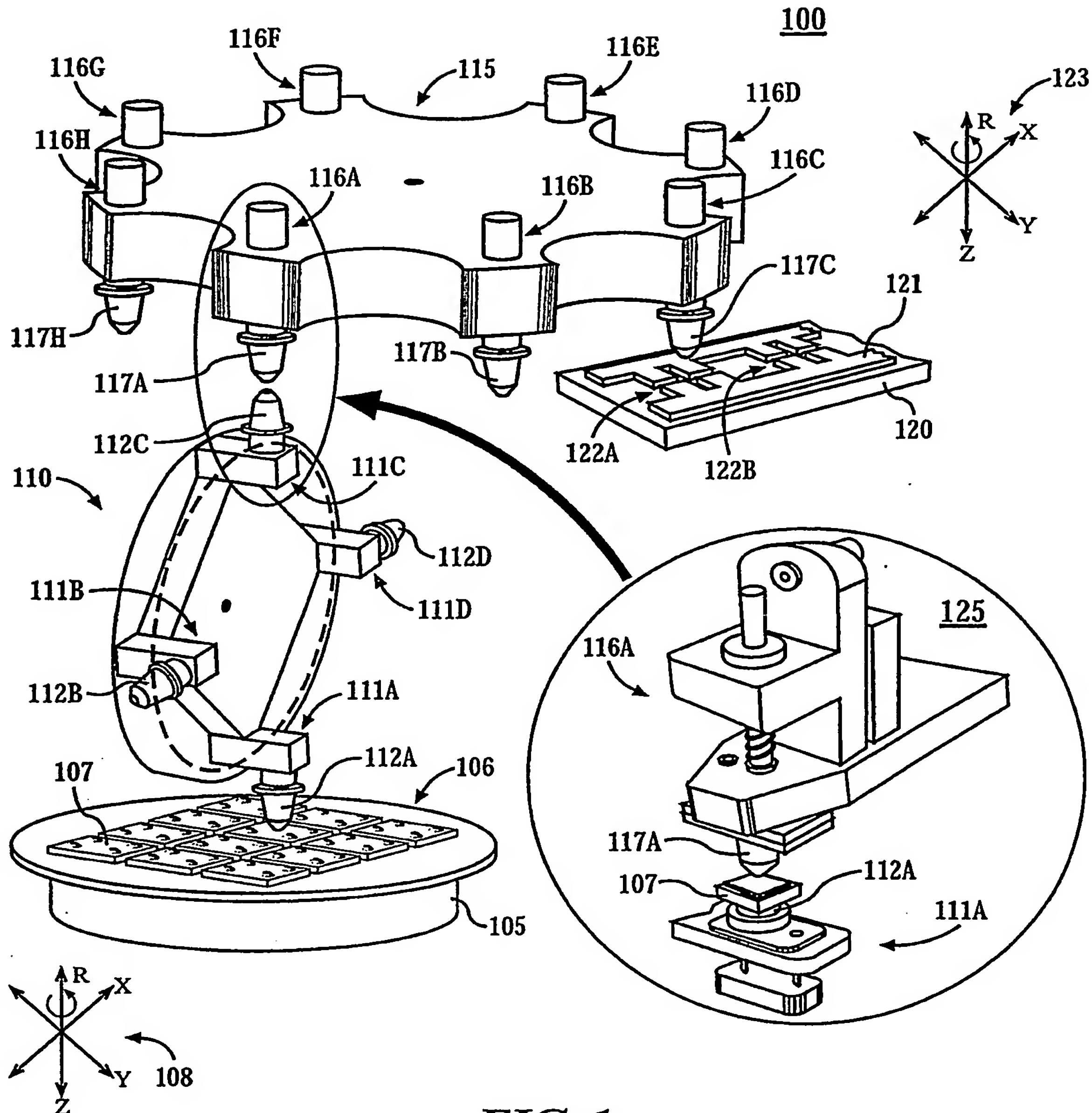
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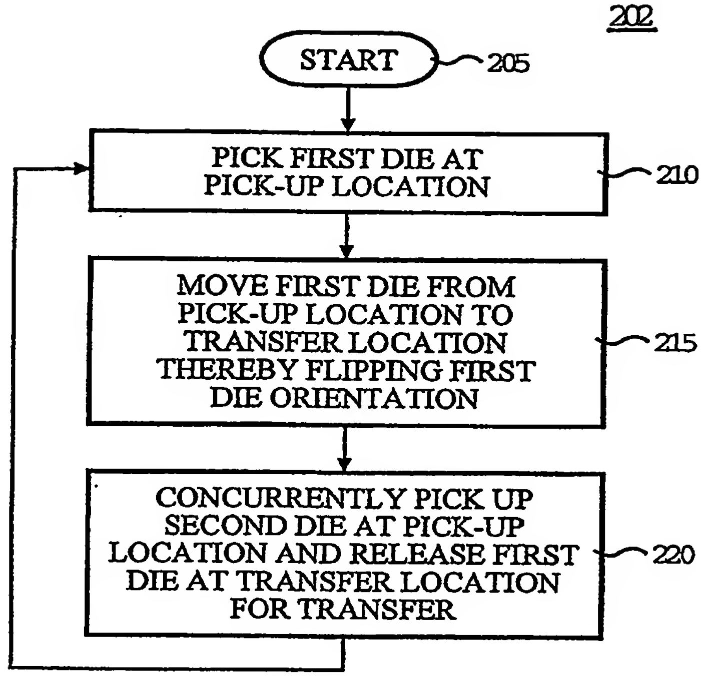
FIG. 1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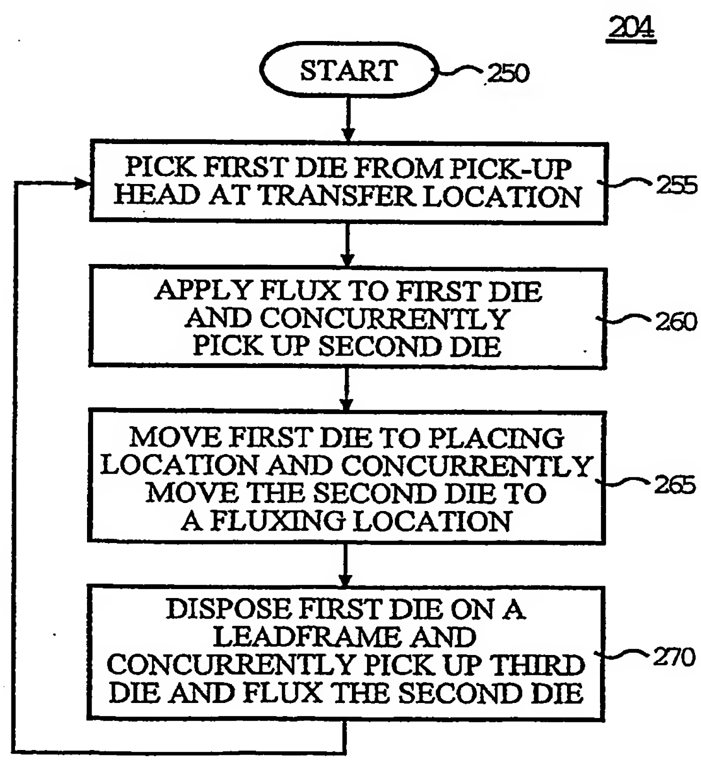
START
205
PICK FIRST DIE AT PICK-UP LOCATION
210
MOVE FIRST DIE FROM PICK-UP LOCATION TO TRANSFER LOCATION THEREBY FLIPPING FIRST DIE ORIENTATION
215
CONCURRENTLY PICK UP SECOND DIE AT PICK-UP LOCATION AND RELEASE FIRST DIE AT TRANSFER LOCATION FOR TRANSFER
220

FIG. 2A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START
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PICK FIRST DIE FROM PICK-UP HEAD AT TRANSFER LOCATION
255
APPLY FLUX TO FIRST DIE AND CONCURRENTLY PICK UP SECOND DIE
260
MOVE FIRST DIE TO PLACING LOCATION AND CONCURRENTLY MOVE THE SECOND DIE TO A FLUXING LOCATION
265
DISPOSE FIRST DIE ON A LEADFRAME AND CONCURRENTLY PICK UP THIRD DIE AND FLUX THE SECOND DIE
270

FIG. 2B

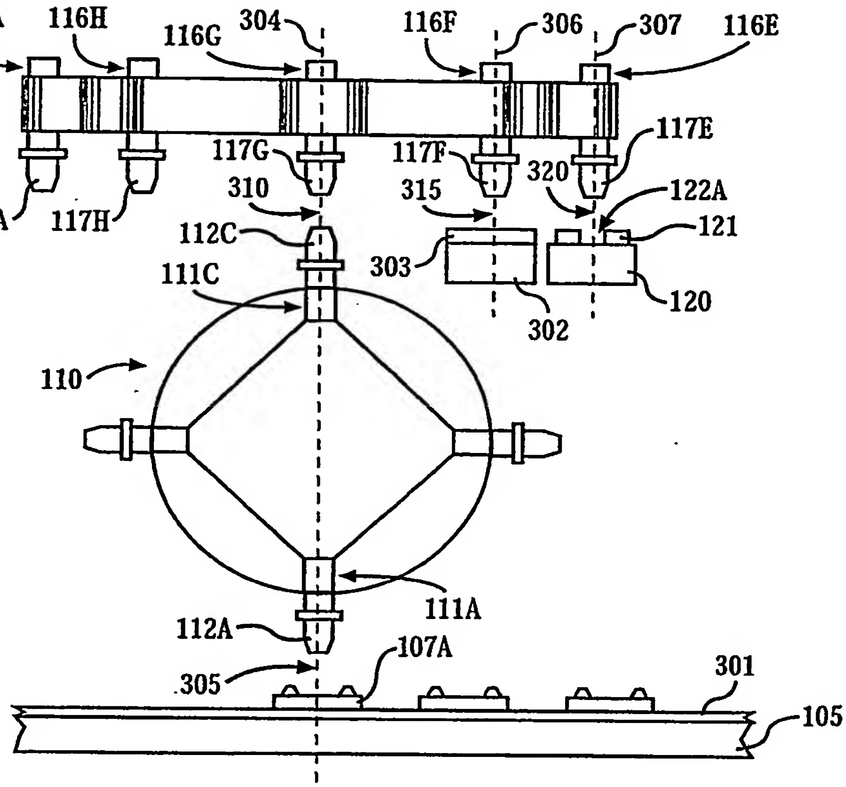
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FIG. 3A

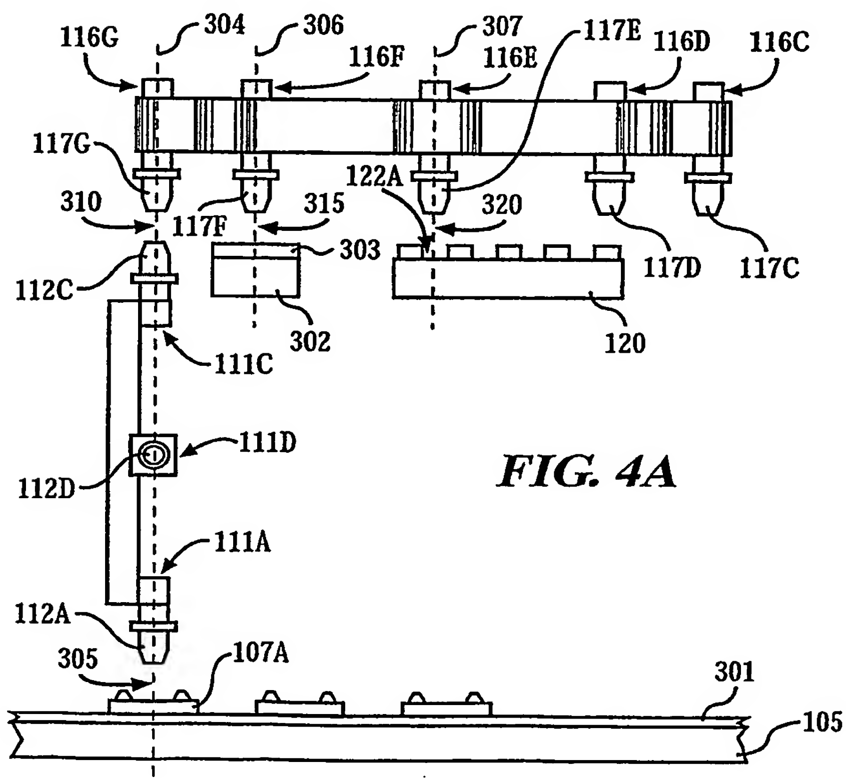
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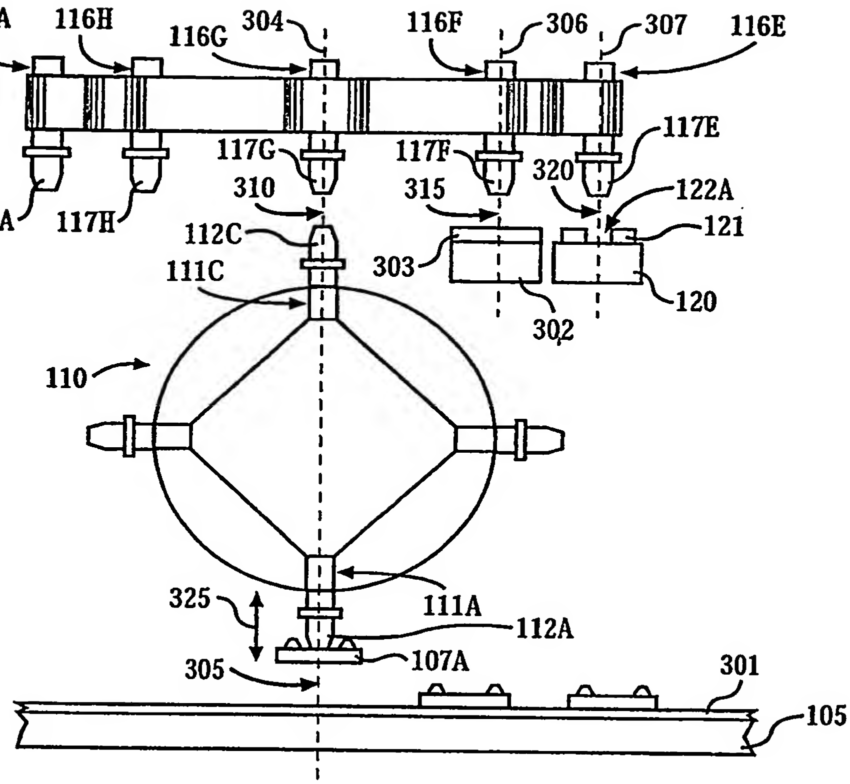
FIG. 4A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105

FIG. 3B

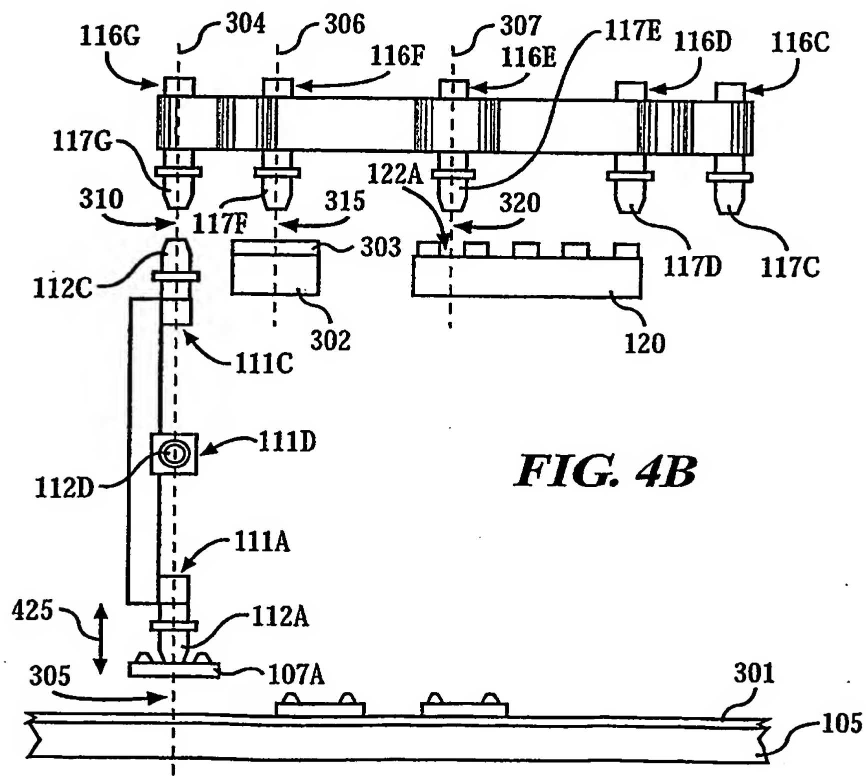
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FIG. 4B

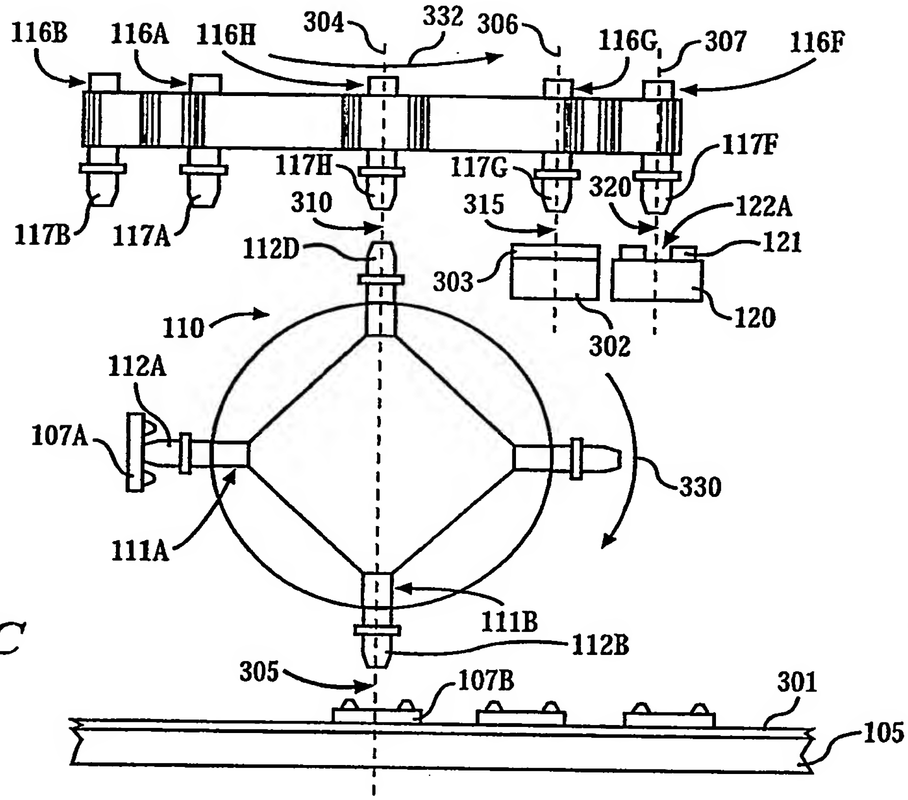
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FIG. 3C

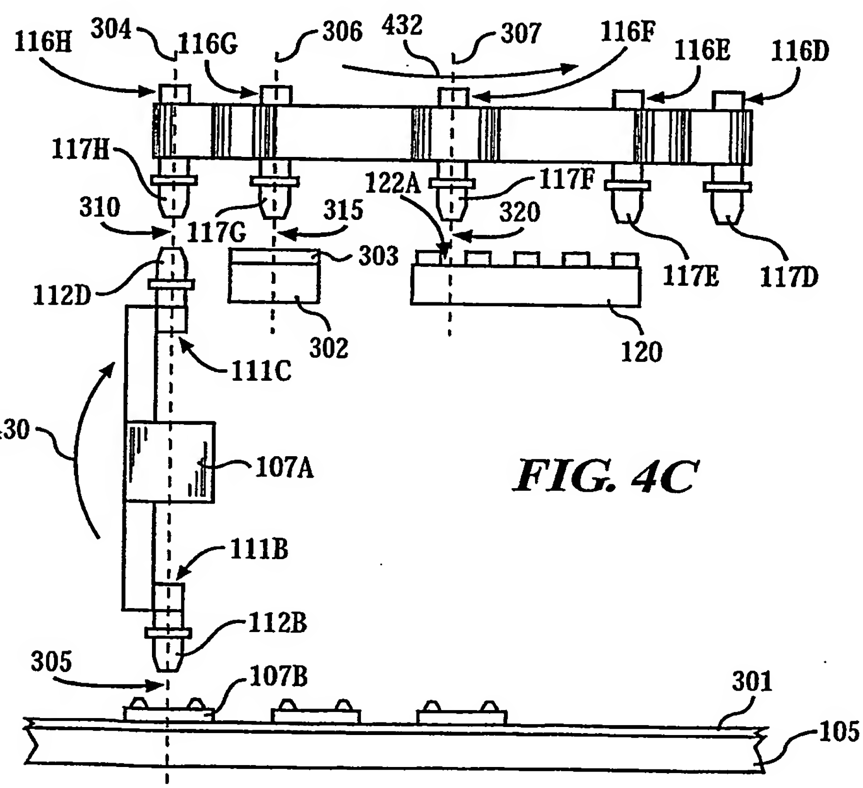
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FIG. 4C

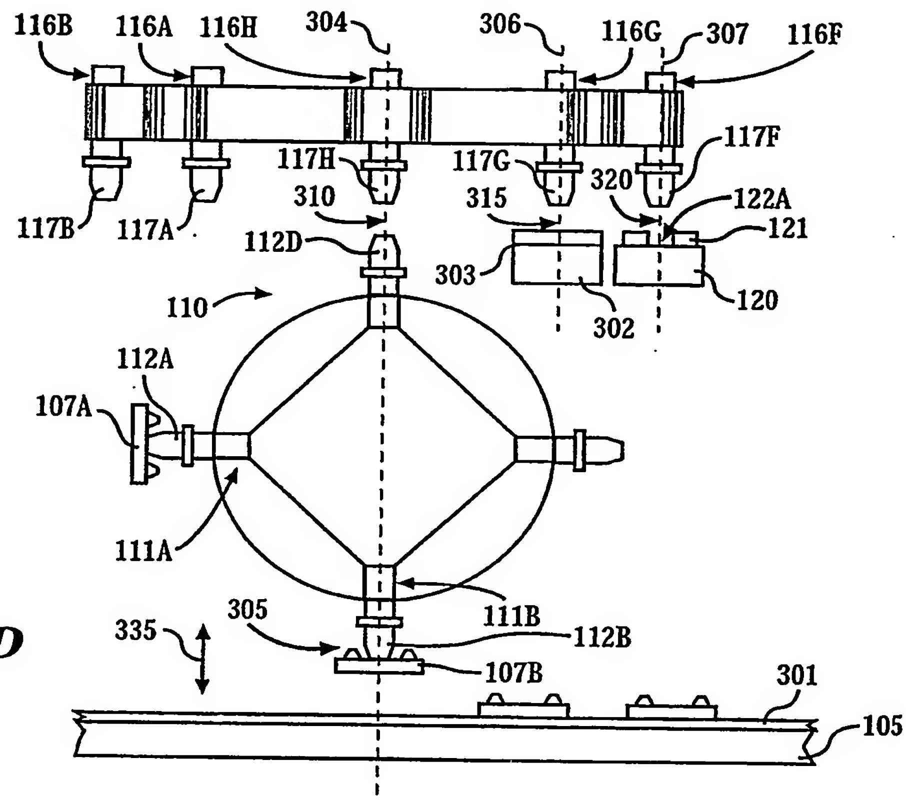
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FIG. 3D

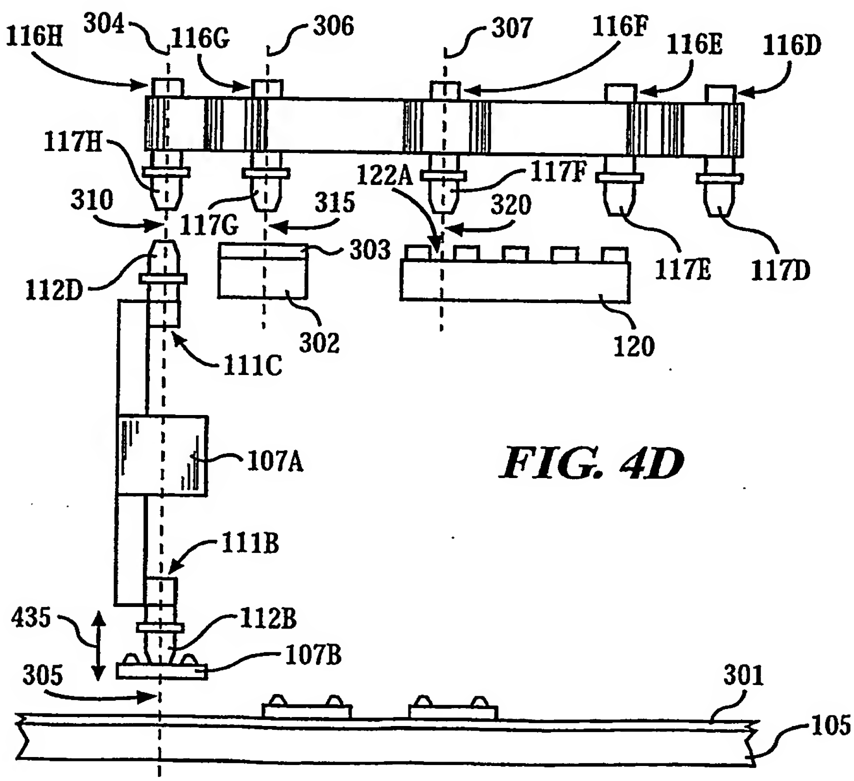
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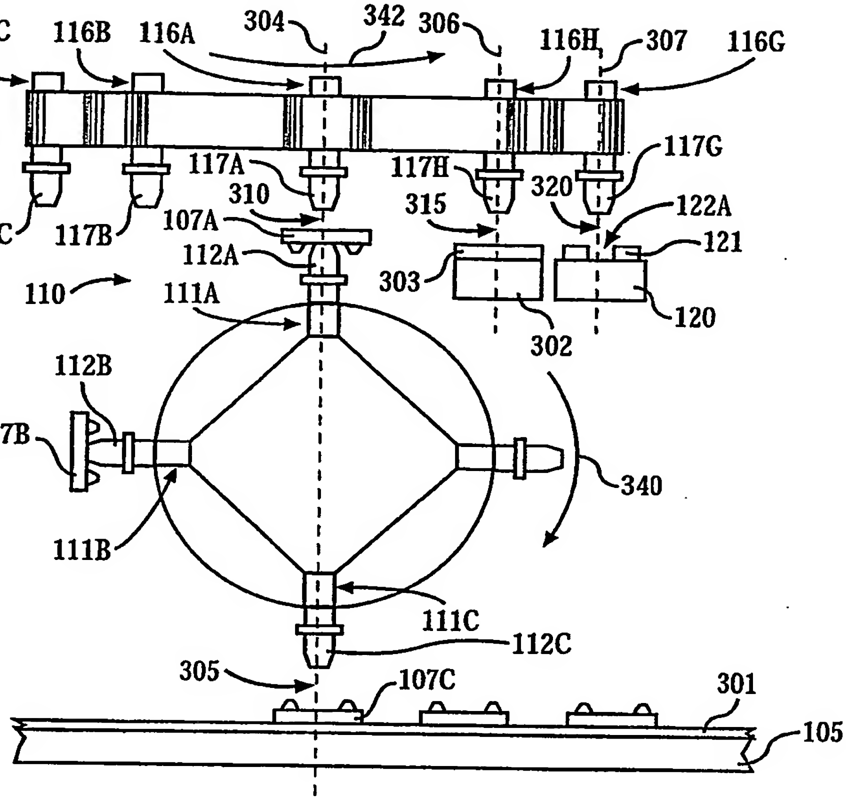
FIG. 4D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121
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107C
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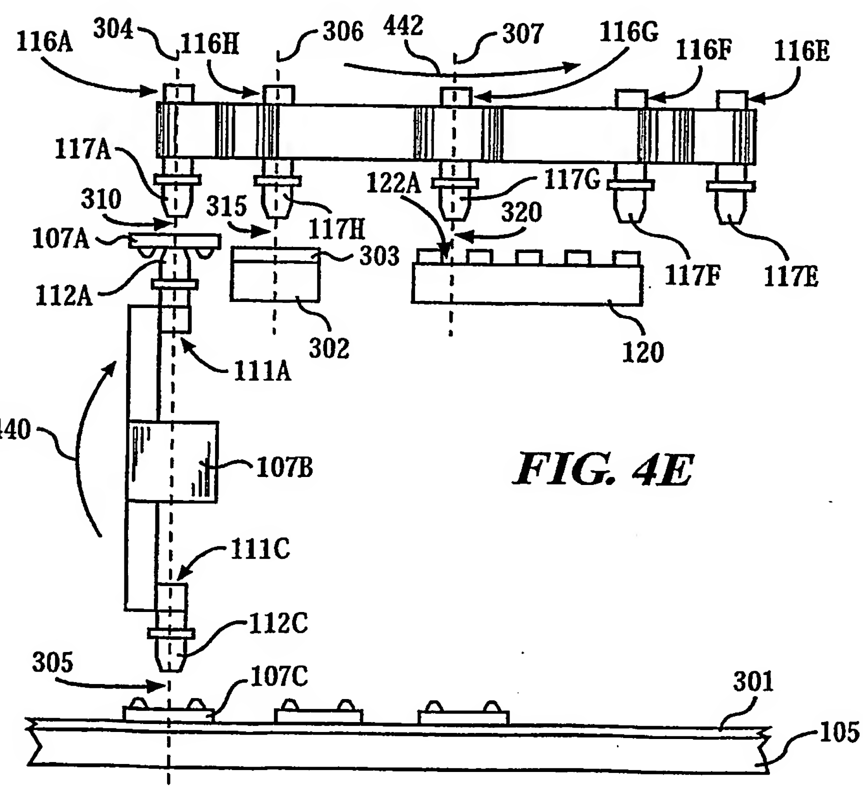
105

FIG. 3E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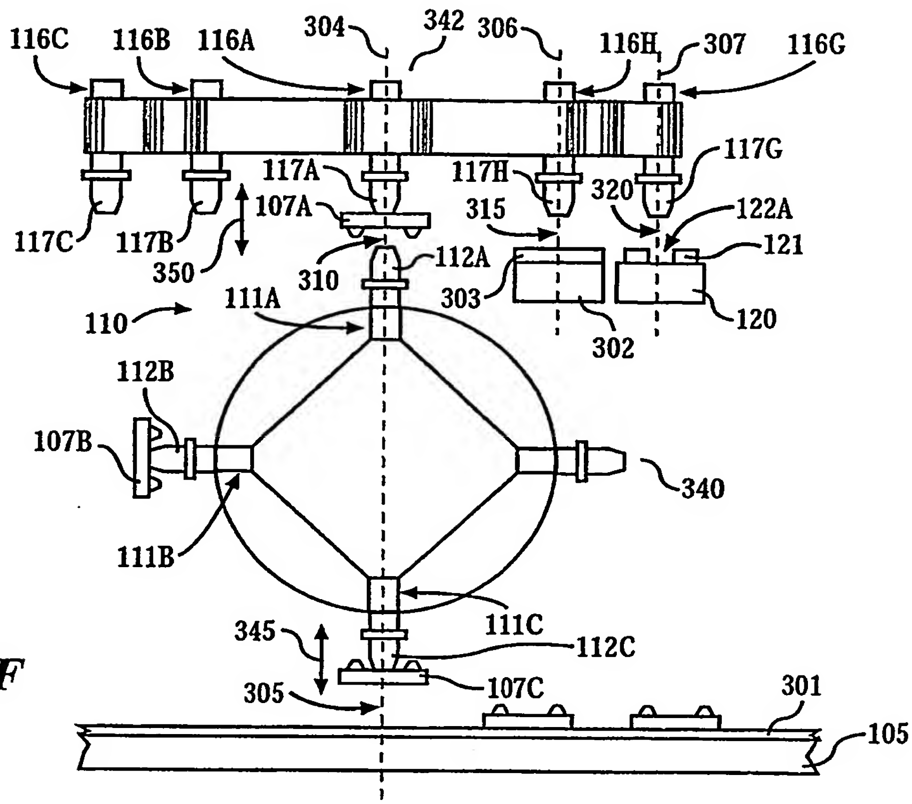
105

FIG. 4E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310
112A
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FIG. 3F

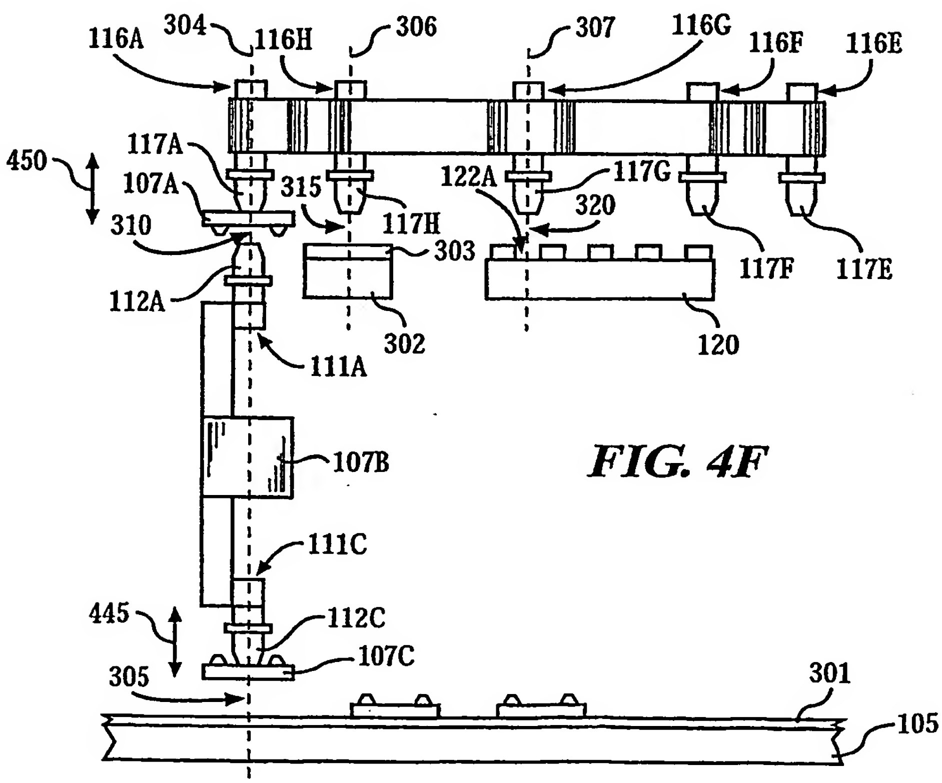
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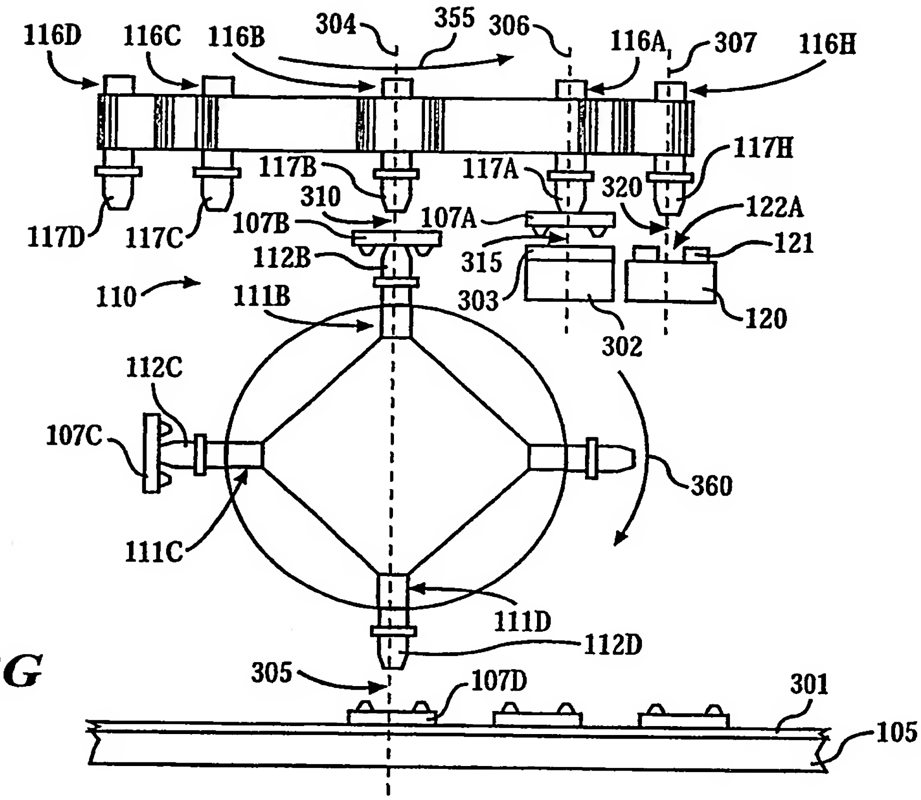
FIG. 4F



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117C
112B
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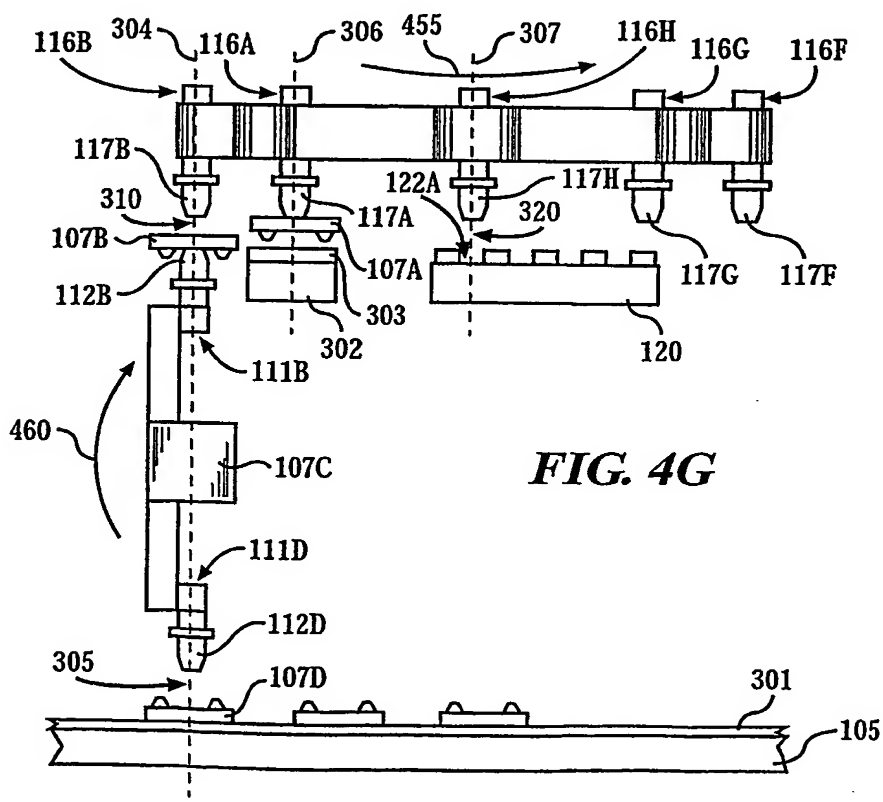
107D
301
105

FIG. 3G



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307
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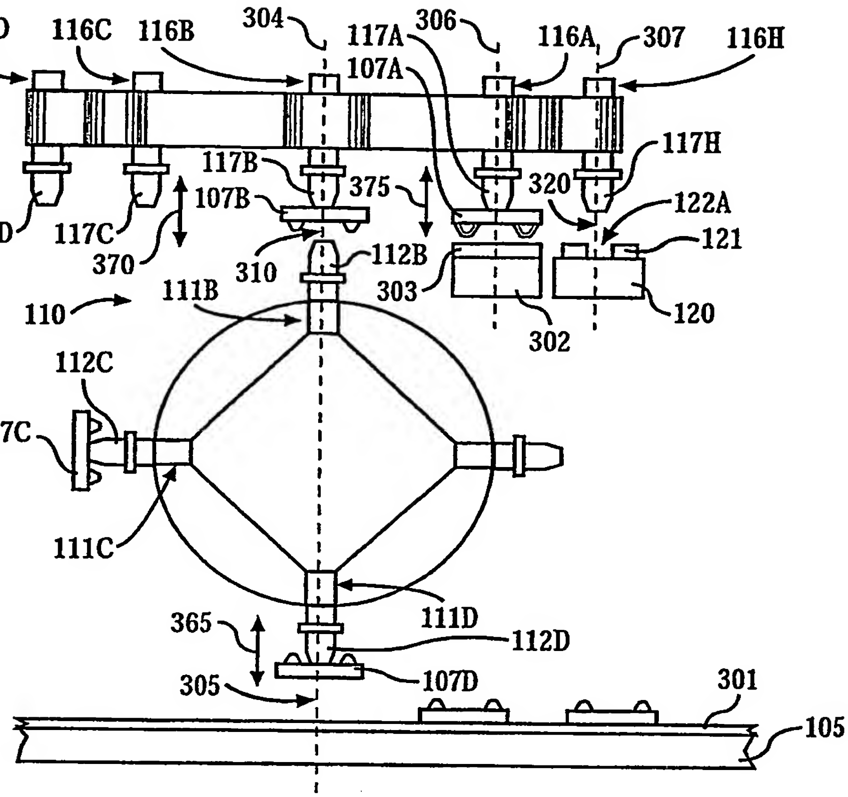
117F
112B
303
302
120
111B
460
107C
111D
112D
305
107D
301
105

FIG. 4G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116B
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116A
307
116H
107A
117B
117H
375
320
122A
107B
121
117D
117C
370
310
112B
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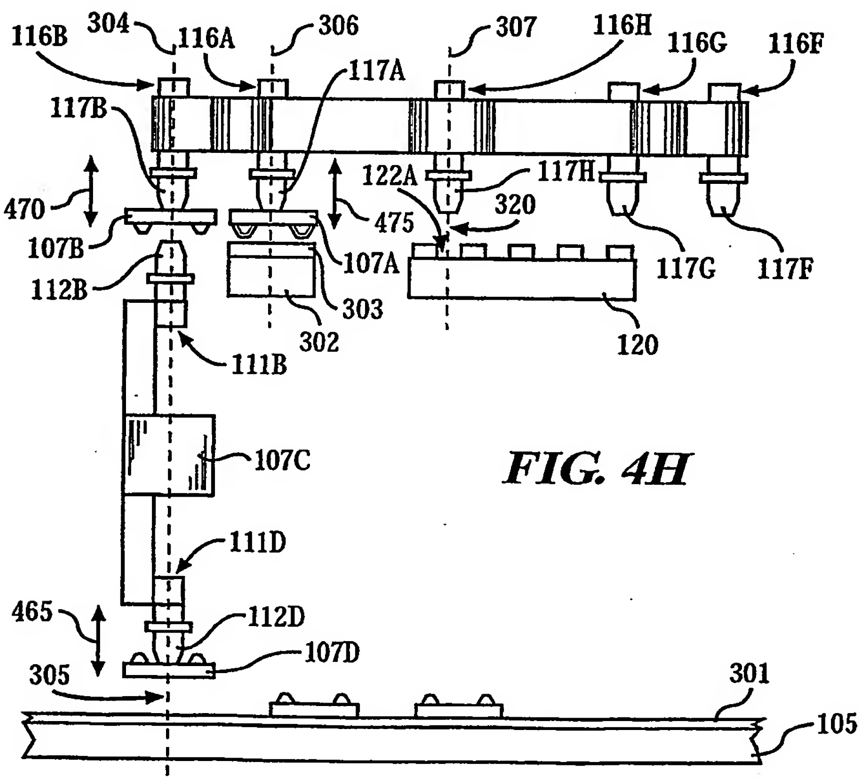
120
110
111B
302
112C
107C
111C
111D
365
112D
107D
305
301
105

FIG. 3H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470
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107B
107A
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117F
112B
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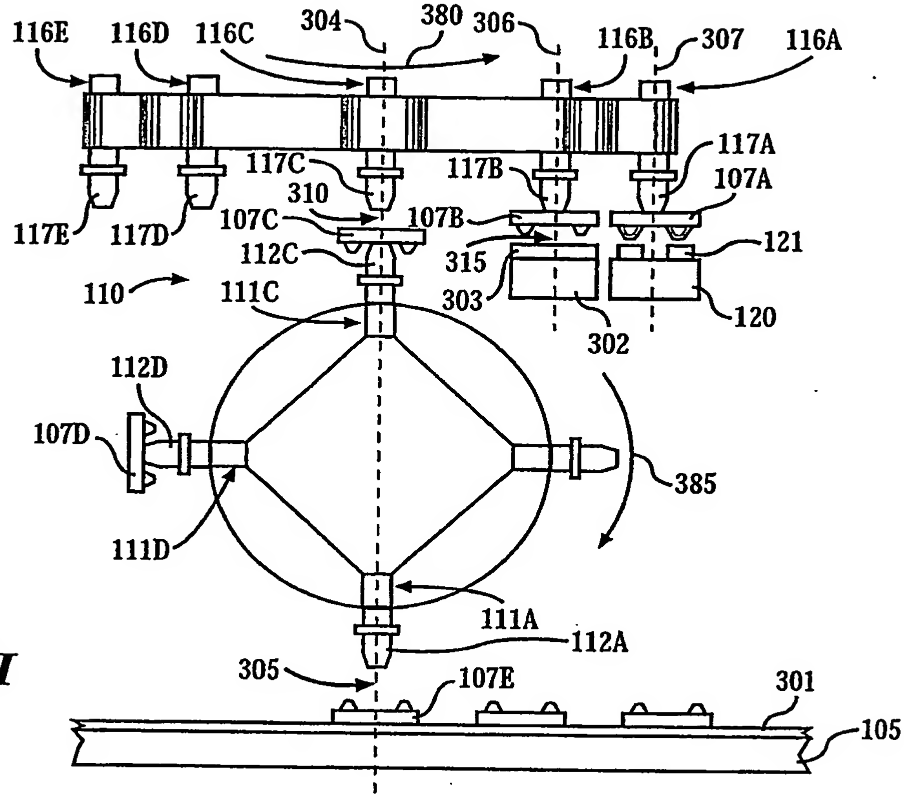
120
111B
107C
111D
465
112D
107D
305
301
105

FIG. 4H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116D
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116B
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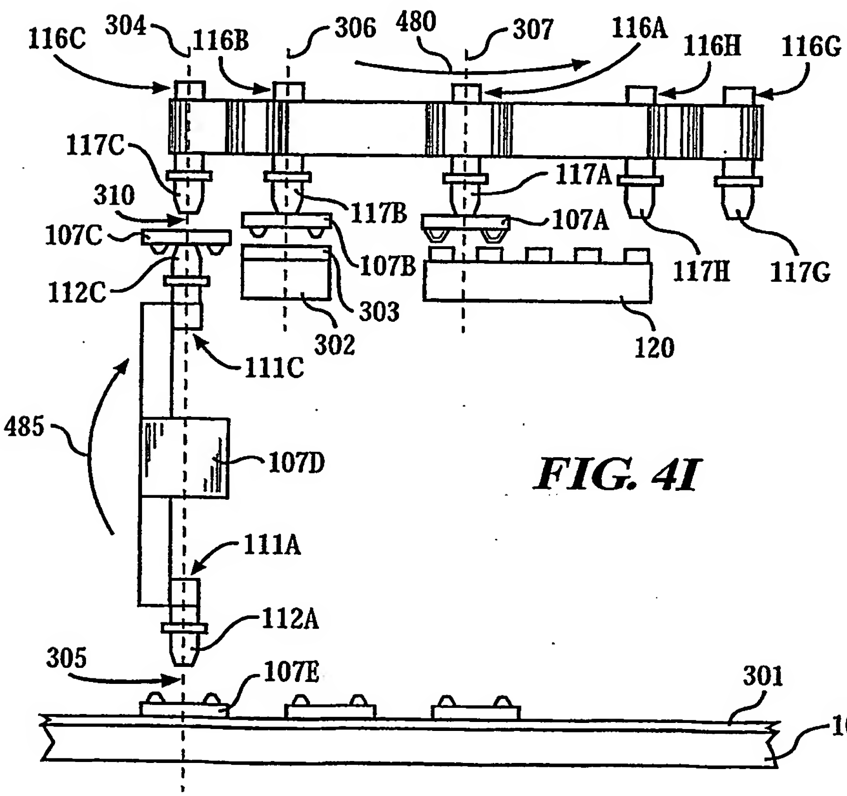
116A
117A
107A
117C
117B
310
107C
107B
117E
117D
112C
315
121
303
110
111C
120
302
112D
107D
385
111D
111A
112A
305
107E
301
105

FIG. 3I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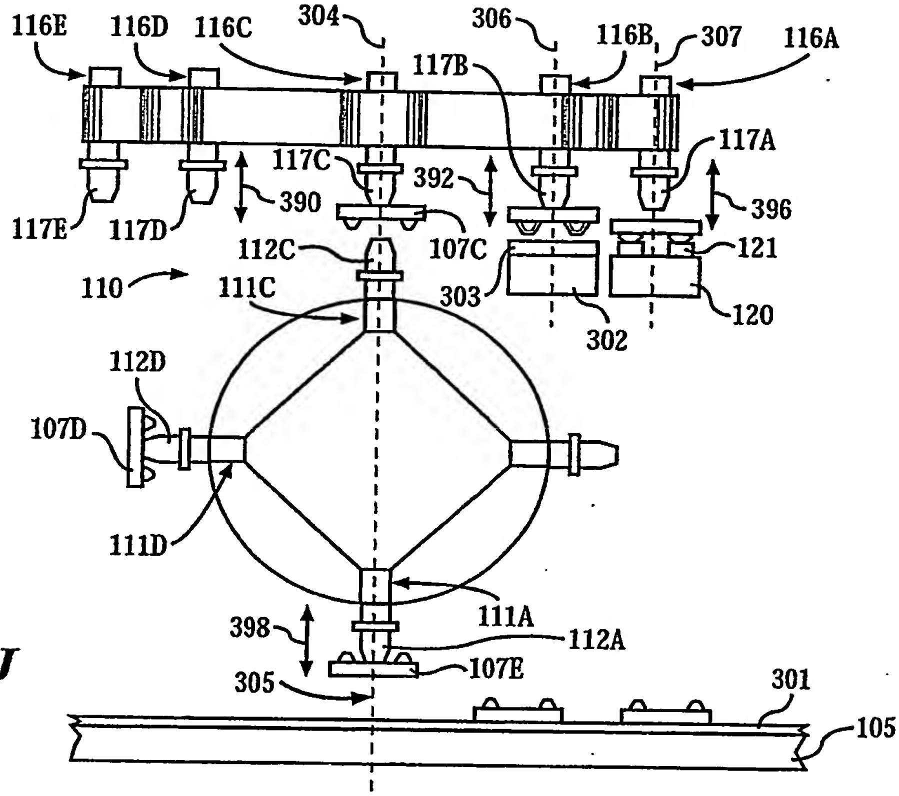
480
307
116A
116H
116G
117C
117A
310
117B
107A
107C
107B
117H
117G
112C
303
302
120
111C
485
107D
111A
112A
305
107E
301
105

FIG. 4I



116E
116D
116C
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116B
307
116A
117B
117A
117C
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390
396
117E
117D
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112C
107C
121
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111C
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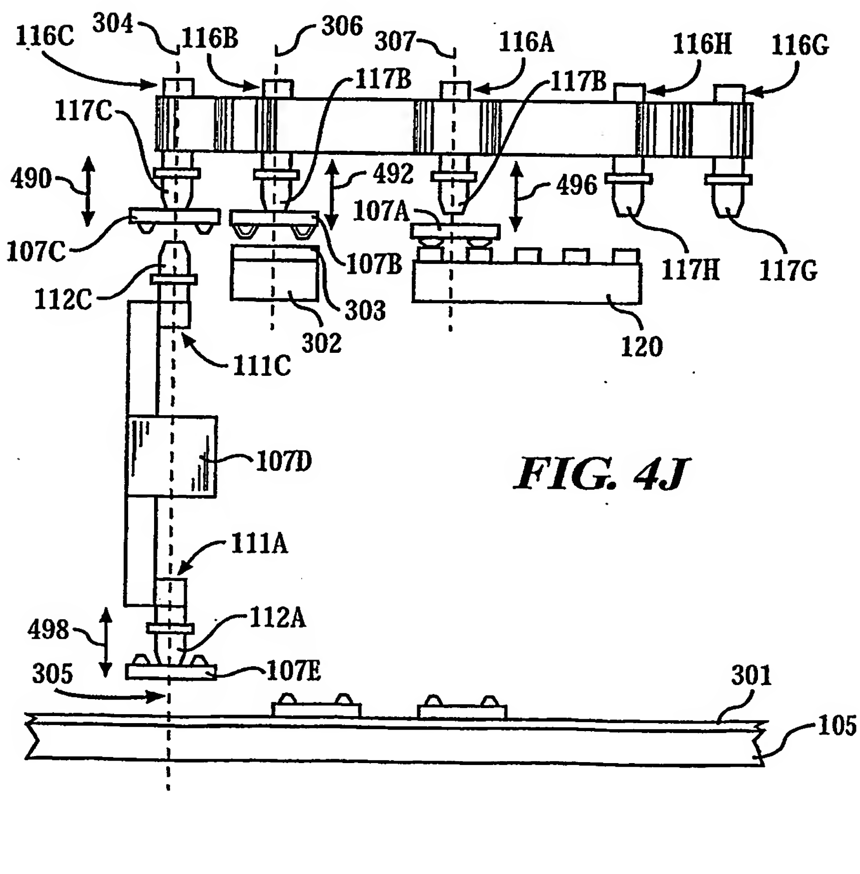
112D
107D
111D
111A
398
112A
107E
305
301
105

FIG. 3J



116C
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116B
306
307
116A
116H
116G
117B
117B
117C
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107A
107C
107B
117H
117G
112C
303
302
120
111C
107D
111A
112A
498
107E
305
301
105

FIG. 4J

INTERNATIONAL SEARCH REPORT

International application No.
PCT/SG02/00286

A. CLASSIFICATION OF SUBJECT MATTER

Int. Cl. 7: H01L 21/68, 21/58, B65G 49/07, 47/91

According to International Patent Classification (IPC) or to both national classification and IPC

B. FIELDS SEARCHED

Minimum documentation searched (classification system followed by classification symbols)
IPC (7) : H01L 21/68, 21/58, B65G 49/07, 47/91, 47/90

Documentation searched other than minimum documentation to the extent that such documents are included in the fields searched
AU : IPC AS ABOVE

Electronic data base consulted during the international search (name of data base and, where practicable, search terms used)
Derwent Patents File : Dwpi

C. DOCUMENTS CONSIDERED TO BE RELEVANT

Category*	Citation of document, with indication, where appropriate, of the relevant passages	Relevant to claim No.
X	WO 99/61678 A (WHITESELL) 2 December 1999. All document.	1,25
X	US 6171049 B (WIRZ et al) 9 January 2001. All document.	1,25
X	US 4653664 A (HINENO et al) 31 March 1987. All document.	1,25
X	JP 11-254367 A (SHIBUTANI KOGYO KK) 21 September 1999. All document.	1,25
X	EP 876957 A (AZIONARIA COSTRUZIONI MACCHINE AUTOMATICHE A.C.M.A. SpA) 11 November 1998. All document.	1,25
X	EP 772229 A (DELCO ELECTRONICS Corp) 7 May 1997. All document.	1,25
X	EP 660657 B (YAMAHA HATSUDOKI KK) 26 August 1998. All document.	1,25

☐ Further documents are listed in the continuation of Box C   ☒ See patent family annex

* Special categories of cited documents:

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- "P" document published prior to the international filing date but later than the priority date claimed
- "T" later document published after the international filing date or priority date and not in conflict with the application but cited to understand the principle or theory underlying the invention
- "X" document of particular relevance; the claimed invention cannot be considered novel or cannot be considered to involve an inventive step when the document is taken alone
- "Y" document of particular relevance; the claimed invention cannot be considered to involve an inventive step when the document is combined with one or more other such documents, such combination being obvious to a person skilled in the art
- "&" document member of the same patent family

Date of the actual completion of the international search	Date of mailing of the international search report
25 February 2003	27 FEB 2003
Name and mailing address of the ISA/AU AUSTRALIAN PATENT OFFICE PO BOX 200, WODEN ACT 2606, AUSTRALIA E-mail address: pct@ipaustralia.gov.au Facsimile No. (02) 6285 3929	Authorized officer DAVID LEE Telephone No : (02) 6283 2107

INTERNATIONAL SEARCH REPORT

Information on patent family members

International application No.
PCT/SG02/00286

This Annex lists the known "A" publication level patent family members relating to the patent documents cited in the above-mentioned international search report. The Australian Patent Office is in no way liable for these particulars which are merely given for the purpose of information.

Patent Document Cited in Search Report		Patent Family Member			
WO	9961678	US	6270536	US	2001051295
US	6171049	EP	883979	WO	9732460
US	4653664	DE	3424323	JP	60012799
JP	11254367	NONE			
EP	876957	BR	9801372	IT	BO 970201
		JP	10324303	US	6283694
EP	772229	SG	86987	US	5671530
EP	660657	JP	7193397	US	5566447

END OF ANNEX